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The Effects of Variations in Gamefish Abundance on Texas Recreational Fishing Demand: Welfare Estimates

by

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ABSTRACT

In an extensive earlier paper (Cameron, 1988a) we developed a fully utility-theoretic model for the demand for recreational fishing access days, applied to a sample of 3366 Texas Gulf Coast anglers. The model employs "contingent valuation" and "travel cost" data, jointly, in the process of calibrating a single utility function defined over fishing days versus all other goods and services. The theoretical specification (quadratic direct utility) and the econometric implementation will not be reproduced here. In this application, we supplement the original data set with information from the ongoing Resource Monitoring Program of the Texas Department of Parks and Wildlife. The RMP concerns all species, but we focus on the abundance of the primary game fish (red drum) across the eight major bay systems and over time. This improves upon earlier studies which utilize endogenous actual catch information. We allow the parameters of the underlying utility function to vary systematically with exogenously measured abundance to assess the impact of this important resource attribute upon the demand for access days. We use empirical estimates (and counterfactual simulations) of equivalent variation as measures of the social value of the fishery under current conditions and under alternative fish stock scenarios.

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DISCLAIMER

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1. Introduction

In Cameron (1988a), we derived and estimated the parameters of a quadratic utility function for a trimmed sample of Texas Gulf Coast recreational fishermen. The utility function, in its simplest form, is defined over fishing access days and all other goods and services (income). The novelty of that paper is primarily its utilization of a fully utility-theoretic framework for analyzing both "contingent valuation" (CV) data (respondents anticipated behavior under hypothetical scenarios) and "travel cost" data (respondents' actual behavior in the consumption of access days). The latter form of data gives us a feel for the consequences of small local variations in access prices; the former provides additional information, however hypothetical, regarding more drastic changes in the consumption environment.

The earlier paper develops the basic specification and goes on to consider several extensions to that basic model: discounting the influence of the CV data in the estimation process; estimation without travel cost data (only income and consumption); and the accommodation of heterogeneous preferences. In the last category, we demonstrated that it is straightforward to adapt these models to allow for systematic variation in the preference function according to geographical or sociodemographic factors.

In this paper, we will again employ heterogeneous utility functions, but we will only be able to exploit a subset of the data. We wish to concentrate upon the potential effects of respondents' perceptions about resource quality on their demand (valuation) of access to the recreational fishery.

Readers are referred to Cameron (1988a) for a vital preface to this research. We avoid extensive duplication in this paper by presuming readers are familiar with the findings of the earlier paper.

2. Outline of the Specification

As before, we will adopt the quadratic family of utility functions, for the same variety of reasons explained in the earlier paper. We will let U denote direct utility, Y will be income, and M will be current fishing day expenditures ("travel costs", roughly). Also, q will be the number of fishing days consumed and z (= Y - Mq) will denote consumption of other goods and services. We will let A denote the abundance of red drum, the primary gamefish species. The quadratic direct utility function will thus take the form:

$$U = \beta_1 z + \beta_2 q + \beta_3 z^2/2 + \beta_4 zq + \beta_5 q^2/2, \tag{1}$$

where the β_j are no longer constants, but will be allowed to vary linearly with the level of A: $\beta_j^* = \beta_j + \gamma_j A,\ j=1,\ldots,5.$

3. Data

The data used for this model consist of a 3318 observation subset of the 3366 observations used in the earlier paper. The data come from an in-person survey conducted by the Texas Department of Parks and Wildlife primarily between May and November of 1987 (although there are a few observations for the first days of December). The primary purpose of the survey is to count numbers and species of fish making up the recreational catch, but during this particular period, additional economic valuation questions were posed to respondents.

In particular, the contingent valuation question took the form: "If the total cost of all your saltwater fishing last year was _____ more, would you have quit fishing completely?" At the start of each day, interviewers randomly chose a starting value from the list $50, $100, $200, $400, $600, $800, $1000, $1500, $5000, and $20,000. In addition, respondents were queried regarding actual market expenditures during the current trip: "How much will you spend on this fishing trip from when you left home until you get home?" This is as close as we can get to a measure of "travel cost."

The same basic criteria for deleting particular observations are applied in this paper as are described in Cameron (1988a). The same caveats regarding the sample also apply in this case. The sample employed in this study is slightly smaller only because our gamefish abundance data are drawn from a separate source: the Resource Monitoring Program of Texas' Department of Parks and Wildlife. We have their data only for April through the end of November, so the few December interviews in the survey sample were simply dropped.

The Resource Monitoring Program uses several types of fishing gear: gill nets, bag seines, beach seines, trawls, and oyster dredges. The Program involves vast numbers of samples being drawn across the entire Gulf Coast. For 1983-1986, we had over 23,000 samples, with complete records of the numbers of individuals of each species collected in the sample. Since low temperatures in 1984 resulted in a substantial fish kill along the Texas Gulf Coast, we utilize only those samples drawn in 1985 and 1986 to construct our abundance measures. Also, only gill nets capture the types of fish that recreational anglers would be seeking, so we use only the catch using this gear type. Still, we have roughly 5400 samples to work with.

One problem, however, is that gill nets were apparently not used during the months of July and August. So we must fill in for missing data for these two months. Fortunately, for each month and each of the eight major bay systems along the coast, we typically have between 40 and 80 samples in each of the two years. Once we have computed mean "catch per unit effort" for each month and each bay, the time series for the April-November data is fairly smooth for the seven most usual species of game fish (red drum, black drum, spotted seatrout, croakers, sand seatrout, sheepshead, and founder). We have used quadratic approximations for the May-October range of the data to fill in abundance estimates for the two missing months.

Preliminary atheoretic logit models based upon the contingent valuation data suggest that among the top three recreational target species -- red drum, spotted seatrout, and flounder -- only variations in the number of red drum have a statistically significant effect upon the implied value of a recreational fishing day. Consequently, we elect to employ only the abundance of red drum as a control for resource quality in this study.

The means and standard deviations for both the full sample of 3366 and the subset of 3318 responses are given in Table 1. As can be seen, the subset is still representative of the larger sample.

4. Utility Parameter Estimates

To assess whether or not the preference function differs systematically with the level of gamefish abundance, we estimate two models. First, we re-estimate the "basic" joint model from the earlier paper using just the subset of 3318 observations. This specification constrains the β coefficients to be identical across all levels of gamefish abundance. Then we generalize the model by allowing each β to be a linear function of A, which involves the introduction of five new α parameters. Since the "basic" specification is a special case of the model incorporating heterogeneity, a likelihood ratio test is the appropriate measure of whether A "matters." Results for the two models are presented in Table 2. The LR test statistic is 8.18. The 5% critical value for a $\chi^2(5)$ distribution is 11.07, and 10% critical value is 9.24. Thus the LR test just fails to reject independence of the utility function from the abundance of gamefish. (However, if one were to generalize the utility function to include only the interaction term zA and its coefficient γ_1, and

Table 1

Descriptive Statistics for Full Sample and "Gamefish Abundance" Subset

Variable	Description	Full Sample (n = 3366)	Subset (n = 3318)
Y	median household income for respondent's 5-digit zip code (in $10,000) (1980 Census scaled to reflect 1987 income; factor = 1.699)	3.1725 (0.6712)	3.2772 (0.6705)
M	current trip market expenditures, assumed to be average for all trips (in $10,000)	0.002915 (0.002573)	0.002927 (0.002576)
T	annual lump sum "tax" proposed in CV scenario (in $10,000)	0.05602 (0.04579)	0.05608 (0.04576)
q	reported total number of salt water fishing trips to sites in Texas over the last year	17.40 (16.12)	17.37 (16.14)
I	indicator variable indicating that respondent would choose to keep fishing, despite tax T	0.8066 (0.3950)	0.8071 (0.3946)
A	Resource Monitoring Program, catch per unit effort of red drum (gill nets) by month and by major bay system	-	0.1487 (0.06161)

Table 2

Parameter Estimates for "Basic"
and "Gamefish Abundance" (A) Models

Parameter	Basic Model (n = 3318)	Abundance Model (n = 3318)
β_1 (z)	3.192 (7.968)	5.039 (6.266)
β_2 (q)	0.1191 (19.18)	0.1133 (10.87)
β_3 $(z^2/2)$	-0.08953 (-1.056)	-0.2622 (-1.322)
β_4 (zq)	0.002661 (1.967)	0.004570 (1.164)
β_5 $(q^2/2)$	-0.006862 (-22.16)	-0.006920 (10.31)
γ_1 (zA)	-	-12.85 (-2.390)
γ_2 (qA)	-	0.03166 (0.5281)
γ_3 $(z^2A/2)$	-	1.191 (0.6256)
γ_4 (zqA)	-	-0.01112 (-0.4287)
γ_5 $(q^2A/2)$	-	0.0004552 (0.1137)
υ[a]	16.03 (81.46)	16.03 (81.38)
ρ	0.2354 (9.187)	0.2343 (9.033)
Log L	-15485.96	-15481.87[b]

[a] See Cameron (1988a) for discussion of the υ and ρ parameters.
[b] χ^2 test statistic is 8.18; at 10% level, $\chi^2(5)$ = 9.24.

none of the other variables or γ coefficients, the incremental improvement in the fit of the model would be statistically significant. The 0.5 percent critical value of a $\chi^2(1)$ distribution is only 3.84.)

5. Implications of Fitted Parameter Estimates

In the earlier paper, several properties of the estimated models were recommended for attention. Here, the properties of the fitted utility function vary across levels of gamefish abundance, A. Consequently, we will examine the fitted utility function at the subsample mean of A (_____) as well as at several other benchmark levels. It is entirely possible to compute values for several interesting quantities for each individual in the sample. Here, however, we will focus initially on the "mean" consumer.

Table 3 summarizes several properties of the fitted utility function for the several levels of gamefish abundance. As expected, changes in gamefish abundance substantially affect the value respondents place on access to this fishery. Value in this case is measured several ways. Compensating variation (CV) is the amount of additional income a respondent would require, if denied access to the resource, to make their utility level the same as that which could be achieved with the optimal level of access. Equivalent variation (EV) is the loss of income which would leave the respondent just as much worse off as would a denial of access. We also compute the equivalent variation for partial reductions in the level of access.

A visual depiction of the effect of gamefish abundance on the preferences of anglers (defined over fishing days and all other goods) is provided in Figure 1 for A = 0.1 and for A = 0.2. As anticipated, indifference curves for A = 0.2 have considerably greater curvature, implying that anglers are less willing to trade off fishing days for other goods when gamefish abundance is higher. In contrast, with lower abundance, the curvature is considerably less, implying that under these circumstances,

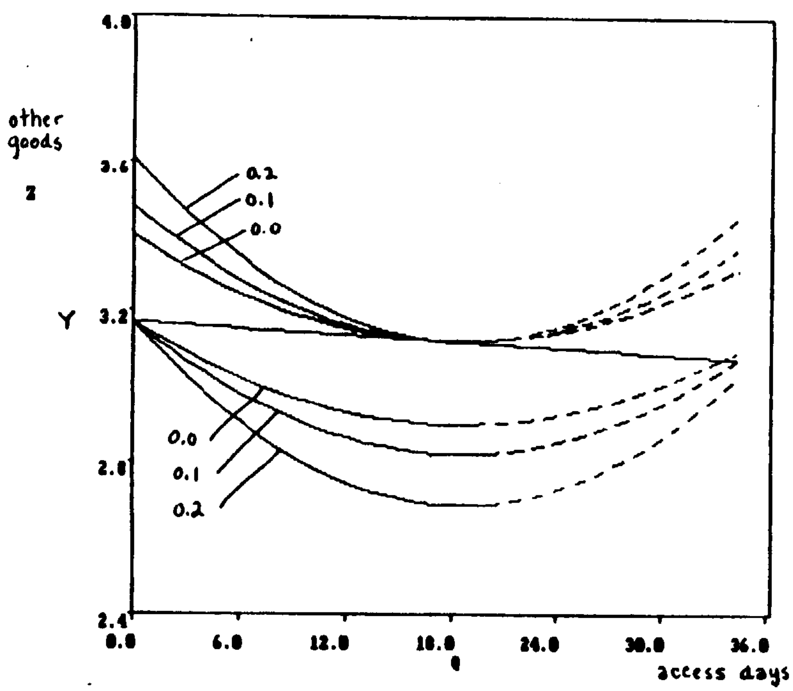

Figure 1 - Effects of changes in the abundance of the primary gamefish on preferences for fishing access days. Empirical indifference curves for mean consumer with abundance at 0.2, 0.1, and 0.0. (Actual mean - 0.149, standard deviation - 0.062, usable sample size n - 3318.)

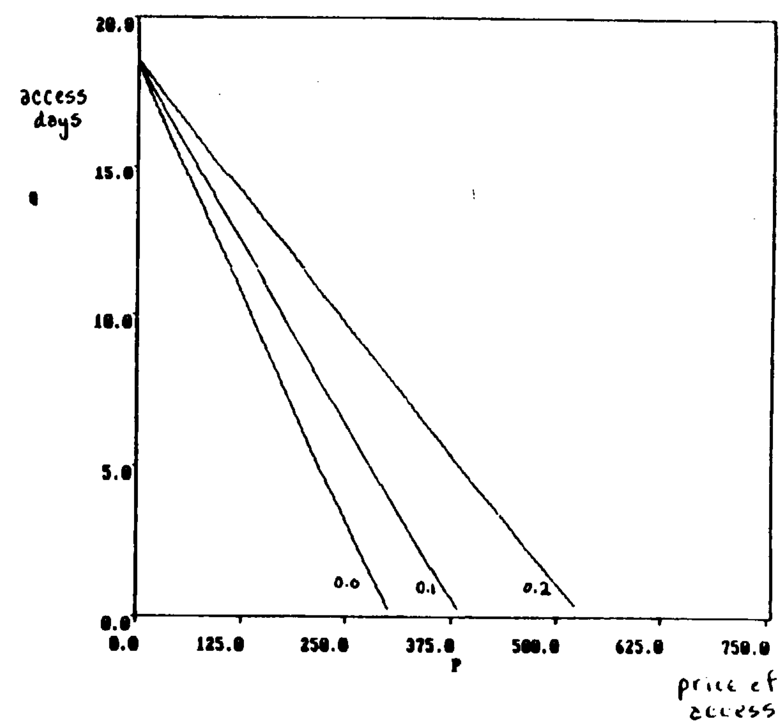

Figure 2 - Empirical inverse demand curves for fishing access days for mean consumer at primary gamefish abundance levels of 0.2, 0.1 and 0.0. (Actual mean - 0.149. standard deviation - 0.062, usable sample size n - 3318.)

anglers consider other goods to be relatively better substitutes for fishing days. For example, when A = 0.1, the same change in the relative price of a fishing day will lead to a larger decrease in the optimal number of days consumed than when A = 0.2.

In addition to the properties of the utility function and its corresponding Marshallian demand functions, we might be interested in calculating the derivatives of these Marshallian demand functions with respect to the level of the A variable. The Marshallian demand function for the model with heterogeneity is:

$$(2) \quad q = [\ (\beta_2+\gamma_2 A) + (\beta_4+\gamma_4 A)Y - (\beta_1+\gamma_1 A)M - (\beta_3+\gamma_3 A)MY\ ] \ / \ [\ 2(\beta_4+\gamma_4 A)M - (\beta_3+\gamma_3 A)\ M^2 - (\beta_5+\gamma_5 A)\ ]$$

Figure 2 plots the inverses of these fitted Marshallian demand functions (with access days q on the vertical axis, and the price of access on the horizontal axis). These demand curves are drawn for an individual with mean income Y and mean travel costs M.

As A varies from 0.0 to 0.1 to 0.2 (compared to the actual mean value of 0.1487), these demand curves shift out further and further. Observe that, although the demand function can be highly non-linear in M, the fitted values of the parameters (for these data and in combination with the sample mean angler characteristics) happen to yield demand functions which are almost linear.

Notice that variations in A, in the fitted model, have rather dramatic effects upon the implied "choke price" (reservation price) for access to the resource: the greater the gamefish abundance, the higher the choke price. This can be interpreted as implying that with greater levels of preferred gamefish abundance, higher and higher prices for access would be willingly paid before individuals will cease entirely to go fishing.

Table 3 also gives the utility maximizing number of fishing days demanded, q, at the sample mean values of M and Y, as a function of the changing levels of gamefish abundance, A. Note that this optimal number of days is not very sensitive to A. This is a consequence of the fact that changes in A seem to have a substantial effect upon the curvature of indifference curves; they have less of an effect on their location.

The variation in the configuration of preferences, and the obvious shifts in the demand curves as a function of A imply that the social value of access to the fishery will depend upon the level of gamefish abundance at fishing sites. To illustrate this sensitivity, we can concentrate upon the equivalent variation for a complete loss of access to the resource, as a function of A, for a representative consumer with sample mean levels of Y and M. These variations can be detected by scanning across the columns in Table 3. Table 3 suggests that for a typical angler, improving gamefish abundance (red drum only) by a factor of 1.5 times its current level of A = .1487 would increase the annual value of access to the fishery by about 36% and improving abundance by 1.2 would increase access values by about 12%. In contrast, decreasing abundance to 0.8 of its current level would decrease the annual value of access by about 10%; decreasing abundance to 0.5 of its current level would decrease access values by 22%. If it is safe to extrapolate these estimates (based on functionally "local" variations in actual abundance levels) to a scenario where red drum are completely eliminated, the loss in access values would be about 37%. (Remaining value would derive from the catch of other species, and from the non-catch utility derived from fishing days.)

6. Discussion and Conclusions

As mentioned above, a full explanation of the empirical innovations embodied in the use of a joint contingent valuation/travel cost model for

Table 3

Properties of the Fitted Utility Function (for "Mean" Consumer)
(n = 3318; valid sample with available abundance data)

Property	at 1.5 (mean A)	at 1.2 (mean A)	at mean A	at 0.8 (mean A)	at 0.5 (mean A)	at A = 0
Utility Function Parameters:						
β_1*	2.173	2.746	3.129	3.511	4.084	5.039
β_2*	0.1204	0.1190	0.1180	0.1171	0.1157	0.1133
β_3*	0.03545	-0.04961	-0.08504	-0.1205	-0.1736	-0.2622
β_4*	0.002089	0.002586	0.002916	0.003247	0.003743	0.004570
β_5*	-0.006818	-0.006838	-0.006852	-0.006865	-0.006886	-0.006920
Function Maximum:						
z*	-528.08	57.40	37.93	29.98	24.16	19.73
q*	-144.18	39.10	33.37	31.23	29.93	29.40
Demand Elasticity wrt						
price	-0.05569	-0.06598	-0.07278	-0.07915	-0.08919	-0.1063
income	0.05568	0.07288	0.08428	0.09529	0.1121	0.1405
Optimal number of Access days (q)	17.65	17.45	17.31	17.17	16.97	16.62
Compensating Variation for Complete Loss of Access	$4873	$4046	$3620	$3266	$2835	$2299
Equivalent Variation for Complete Loss of Access	$4796	$3943	$3515	$3164	$2741	$2221
EV for Access Restricted to α of Current Fitted Level, for a =						
0.1	$3885	$3196	$2850	$2566	$2223	$1801
0.2	3069	2527	2254	2029	1758	1425
0.3	2350	1936	1727	1555	1348	1092
0.4	1726	1423	1270	1143	991	803
0.5	1199	988	882	795	689	558
0.6	767	633	565	509	441	357
0.7	431	356	318	286	248	201
0.8	192	158	141	127	110	89
0.9	48	40	35	32	28	22

valuing a recreational fishery is given in Cameron (1989). This paper represents a specific generalization of the model which allows the parameters of the direct quadratic utility function to vary systematically with the level of just one species of gamefish. We have selected the most popular gamefish species (red drum). A more elaborate model, of course, could let the utility parameters vary systematically with any number of characteristics of the resource, not just the abundance of a single species of gamefish.

Since we concentrate only upon red drum abundance, even the reduction to zero of red drum stocks (in the most extreme simulation described in the last section) will not lead everyone to cease fishing entirely. Other species of gamefish will remain. In this specification, variations across location and month in red drum abundance may be correlated with the abundance of other species. If this is the case, our red drum abundance measure will be capturing variations in the abundance of more than one species. Nevertheless, we do not capture the distinct effects of any seasonal or location variation in species abundance that is uncorrelated with red drum abundance.

The simulated variations in red drum abundance used as illustrations in this paper are by far the coarsest simulations that could be generated by a model such as this. We have concentrated solely on variations in abundance as they would affect a representative consumer with mean income and travel costs. However, since each individual's estimated preference function depends on the abundance of red drum during the month and in the bay system in which they are fishing, the model is perfectly able to simulate the impact upon the value of fishery access to individuals of forecasted changes in red drum abundance either by month or by geographical area. As the configurations of individuals' indifference curves change, so will their optimal number of fishing days and the equivalent variation associated with partial or complete loss of access.

The intent of this paper, therefore, is to illustrate the versatility of the constrained, jointly estimated contingent valuation/travel cost model for recreational fisheries valuation. It is satisfying to find thoroughly plausible changes in economic quantities as a consequence of exogenous variations in resource characteristics. This generalization of the "common utility function" model to a "systematically varying utility function" model should serve as a very useful prototype for subsequent research.

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